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ON THE

Causes of the Spread of Pulmonary Consumption

AND OTHER TUBERCULAR DISEASES,

AND ON THE MEANS WHICH MAY BE TAKEN TO PREVENT THEIR DISSEMINATION.

[FROM THE *PROCEEDINGS* OF THE PHILOSOPHICAL SOCIETY OF GLASGOW.]

On the Causes of the Spread of Pulmonary Consumption and other Tubercular Diseases, and on the means which may be taken to prevent their Dissemination.

By Eben. Duncan, M.D., Physician to the Victoria Infirmary; Examiner in Clinical Medicine in the University of Glasgow; and Vice-President of the Sanitary Association of Scotland.

[Read before the Society, 30th March, 1892.]

The chief members of the group of tubercular diseases are—

1. Phthisis pulmonalis (consumption of the lungs);
2. Tabes mesenterica (consumption of the bowels);
3. Tubercular meningitis (water in the head); and
4. Scrofulous disease, so common in the glands, the bones, and the joints.

But, in addition to these, we have a multitude of diseases in all parts of the bodies of men and of the lower animals in which tubercular disease is the essential element. There is no other class of ailment affecting animal life so wide-spread and so destructive. The experiments of Koch, the discoverer of the tubercle bacillus, have proved not only the presence of that micro-organism in every one of these tubercular diseases, but also the important fact that by the inoculation of a pure cultivation of the bacillus, grown in coagulated blood serum, diseases exactly similar can be induced in the bodies of all warm-blooded animals. Koch's experiments have been confirmed by numerous reliable men in all parts of the world. There is, therefore, now no reasonable ground for doubting Koch's statement that, in whatever organ or tissue tubercular or scrofulous disease may be found, the actual exciting cause of the disease is the tubercle bacillus.

This bacillus is a micro-organism which is seen under a high power of the microscope as a rod-like body measuring in length

from one-fourth to one-half of the diameter of a red blood corpuscle—that is to say, $\frac{1}{6000}$ to $\frac{1}{12000}$ of an inch.

These minute rod-like bodies are not quite straight, but are curved in form, and often show slight breaks or bends in their contour. It is now ascertained that they are true parasites, and complete the whole cycle of their life-history in the body of their host. They propagate by resting spores (two to six in number), which retain their vitality with great tenacity even outside of the body, and under circumstances most unfavourable to their development. It has been proved by inoculation experiments that the tubercle spores, in such matter as dried sputum of phthisical patients, may retain their virulence for a period of six months. While the bacilli and their spores retain their vitality they cannot develop and propagate themselves otherwise than within the bodies of human beings or of other warm-blooded animals. It is only with the greatest care that they can be grown experimentally on such organic matters as coagulated blood serum when specially prepared and constantly kept about the same temperature as the human body, and, further, when they are protected from the other bacteria, the spores of which float in the dust of the atmosphere. Under these experimental circumstances it is found that the spores of the tubercle bacillus grow very slowly, and only come to full maturity in from three to four weeks. From the great difficulty experienced in growing them experimentally, we may conclude that the tubercle bacilli found in nature have all been grown in the body of some animal suffering from tuberculosis. Tubercular diseases are, therefore, typically communicable and contagious diseases. If, then, their cause, the tubercle bacillus, cannot come from any other source than the body of some animal affected by tuberculosis, it follows (1) that if we could destroy all the animals in the world at present suffering from tuberculosis, and all their diseased excreta, we would at once abolish tubercular diseases ; or (2) if we could render the body of a man or of an animal an unsuitable soil for the growth of the parasite, then that man or that animal would be as completely protected from tubercular disease as if we had destroyed the whole race of tubercle bacilli.

Death-Rate from Tubercular Diseases in Great Britain.

As shown by the returns of the Registrar-General, twenty years ago, the annual death-rate from tubercular diseases in Scotland

averaged 17·29 per cent. of the total deaths. In the last published volume of abstracts of mortality (1889) this average death-rate was shown to have fallen to 13·4.

The fall in the death-rate from this class of diseases during the past twenty years is equally marked in England. There, in the five years 1866-70, the average annual death-rate from tubercular diseases was 3,199 per millon, whereas in the years 1886-90 the rate per million had fallen to 2,321.

At the present rate of mortality I calculate that, in round numbers, 10,000 persons die annually from these diseases in Scotland, and 67,000 persons in England, giving a total of 77,000 deaths annually from tubercular disease in Great Britain. The majority of these deaths are due to phthisis pulmonalis, popularly known as consumption of the lungs. I here give the actual number of deaths for one year, as stated in the latest reports of the Registrar-Generals of England and Scotland :—

	Scotland.	England.	Total.
Deaths from all tubercular diseases, . .	9,722	67,528	77,250
Deaths from phthisis pulmonalis, . .	7,098	47,634	54,732

Even this large number does not suffice to indicate the disastrous effects of these maladies. Every physician knows that a large proportion of the numerous deaths registered under the names of bronchitis and inflammation of the lungs are really due to tubercle. Apart altogether from errors due to difficulty of diagnosis, where there is any loophole by which it is possible to escape from the stigma of tubercular taint in a family, it is eagerly seized upon, and death is attributed by the relatives to any other cause that can be made to look feasible.

Life insurance companies, therefore, believing in the heredity of phthisis, inquire most carefully into such indefinite causes of death in relatives as childbed, &c., with the result that in many cases the death so registered turns out to have been the termination of a long-standing illness, which had all the symptoms of consumption of the lungs. Taking all these facts into consideration, I think I am much nearer the truth when I state the annual death-rate from tubercular disease in Great Britain at 100,000. We have no means of ascertaining with accuracy the number of persons who suffer from tubercular diseases in proportion to the number who die of these maladies. But, considering the chronic character of tubercular ailments (most of them lasting for years, and many of them ending in recovery), I think I am justified in

stating that for every death there are at least ten persons suffering from some form of tubercular ailment. I thus arrive at the conclusion that, as the average annual death-rate is about 100,000, there is an average number of 1,000,000 persons in Great Britain constantly suffering from the dangerous effects of the tubercle bacillus in some form. Out of that number 700,000 persons are suffering from consumption of the lungs.

The death-rate from tubercular diseases among the domestic animals cannot be accurately ascertained, but from the Report of the Parliamentary Committee on Pleuro-pneumonia and Tuberculosis, published in 1888, and from other sources, I think it highly probable that, in proportion to their numbers, the amount of tuberculosis among dairy cattle is even greater than it is in the human population. The grounds on which I found my statement as to the great prevalence of tuberculosis in dairy cattle are as follow :—

1. At a meeting of the Sanitary Association of Scotland, held in Edinburgh last September, Professor M'Fadyean, of the Royal Veterinary College, stated that he found 23 per cent. of the milk cows which he had an opportunity of examining *post-mortem* were tubercular. He further stated that about 20 per cent of all the dairy cows in Scotland would probably be found to be tubercular, and that in this respect the country dairies were worse than the town dairies.

2. At the same meeting Principal Whalley stated that a short time previously he had ordered the slaughter of eleven perfectly healthy-looking cows on account of pleuro-pneumonia, and that seven of these were found to be tubercular.

3. In the Report of the Royal Commission on Pleuro-pneumonia and Tuberculosis, Mr. John Spier, of Newton Farm, stated to the Committee that two local authorities in his neighbourhood, after examination of all the herds of cattle in Paisley and Glasgow, came to the conclusion that 30 per cent were more or less affected with tuberculosis.

4. Mr. Cornelius Cunningham, V.S., stated on evidence to the same Committee that he had occasion to kill sixteen Ayrshire cattle, and that of these four were tubercular—that is to say, 25 per cent. Some of these showed no signs of it whatever during life. Professor M'Call stated that in a farm near Glasgow twenty-five Ayrshire cows were turned out to the fields in May, and twelve of these

died from tuberculosis before the New Year, and several others showed symptoms.

The prevalence of tubercular diseases among domestic animals is a serious danger to the public health, because there is now no doubt that the flesh and milk of tubercular animals are important factors in spreading tuberculosis amongst the human population. It is now a well ascertained fact that tuberculosis is common not only among bovines, but also in swine, fowls, and other domestic animals, the flesh of which may convey the disease to man.

According to the Report of the Parliamentary Committee already referred to, the order of liability to tuberculosis among animals is as follows:—(1) Man; (2) milch cows; (3) fowls; (4) rodents; (5) pigs; (6) goats; (7) sheep; (8) horses; (9) carnivora, dog and cat, &c., rarely.

There are, in round numbers, 2,400,000 milk cows in Great Britain, and if Professor M'Fadyean's estimate is correct, nearly 500,000 of these are tubercular, and are actively disseminating the tubercle bacillus or its spores by their milk when living, and by their flesh when dead.

More than two thousand years ago the doctrine of the contagious nature of pulmonary consumption, which is the chief member of the group of tubercular diseases, was referred to by Aristotle as a commonly acknowledged doctrine among the Greeks of his day. In the second century of the Christian era, Galen, the most eminent physician of his time, taught the same doctrine in Rome, and cautioned attendants on consumptive patients against the danger of being constantly about their persons through the whole course of the disease. In more modern times the Italians, the Spaniards, and the Portuguese have been the chief supporters of this view. I extract the following from the returns to the Investigation Committee of the British Medical Association on the communicability of phthisis. Dr. John Gason, of Rome, writes:—"So prevalent in Rome is the idea of its communicability, that at the Hospital of St. John Lateran for Women there is an upper ward reserved solely for such cases, which will not be admitted into the general wards. When a poor person dies in Rome of that disease, at their own home, the family almost invariably leave it, and go into another apartment." Dr. Underhill writes:—"Some years ago, when travelling through country districts in Spain, I found a common notion prevailing among the lower orders that phthisis

was contagious. They never used a room where a person had died of phthisis without first thoroughly disinfecting it." Dr. Brant, of Oporto, writes:—"Among the Portuguese and Spaniards it is a popular belief that phthisis is contagious. During illness a separate set of crockery, knives and forks, spoons, and bedclothes, is put aside for their especial use. After death, bed and linen are destroyed." In this country many individual physicians have acknowledged the doctrine of contagion in a modified and hesitating manner. For instance, in the early part of this century, Dr. John Mason Good, in his "Study of Medicine," writes:—"I have myself been witness to various cases which could not be ascribed to any other cause." . . . "The disease, however, is but slightly contagious, admitting it to be so at all, and seems to demand long and intimate communion, as, for instance, sleeping or constantly living in the same room, to render the miasm effective."

Notwithstanding the discovery of the tubercle bacillus and the demonstration of its infective power, the hesitating and modified opinion expressed by Dr. Good in 1825 is, I believe, the opinion of most physicians in this country at the present time. Some bacteriologists and pathologists are inclined to go further than the facts seem to warrant, and to magnify the importance of the seed at the expense of the soil. Some pathologists have even cast doubt on the old doctrine of heredity, and on the important influences of bad sanitary surroundings in fitting the tissues to form a proper soil for the growth of the seed; with them the fact of contagion overshadows all other considerations. The practical physician in his daily work does not see much evidence of immediate contagion from patient to patient. Many physicians of great experience do not believe that, apart from the influence of heredity and bad sanitary surroundings, tubercular diseases can propagate themselves. From a clinical point of view, the case was summed up a few years ago by the late Dr. Wilson Fox, an eminent authority on such matters:—"There are," he says "few writers who have not admitted the possibility of some contagion, but I venture to think that the evidence as it stands shows that even if this possibility has an authentic foundation, the extent and degree to which contagion ordinarily extends is singularly small." If, he says, tuberculosis depends exclusively on the effect of bacilli introduced into the body, these may owe their power of germination in certain tissues to the weakening of the latter by disease or otherwise.

On account of this conflict in opinion, in the year 1883 a Committee of the British Medical Association sent a circular to the medical practitioners of Great Britain, asking them whether in their practice they had observed cases in which pulmonary phthisis appeared to be communicated from one person to another. The Committee received 1,078 returns, of which only 261 were in the affirmative. I have read over all the affirmative replies, with the result that, while in about one-half of the answers the details given are not sufficiently detailed to permit me to form an opinion as to the value of the evidence, some of them, however, are sufficiently detailed to enable me to say that they are quite worthless as evidence of contagion. I shall read a few cases to illustrate this class of replies (Cases 53,* 166, 121, 134, 148).

But there are 130 replies in which sufficient detail is given to enable me to say that there is a great probability that direct contagion did take place. And what strikes me very forcibly in these affirmative evidences is the frequency with which the writer draws attention to the fact that the patients lived in most insanitary surroundings (see Cases 70, 87, 168, 169, 172, 191 †). A large proportion of these were cases of the disease being communicated from husband to wife. There are given 119 cases of wife infection from a deceased husband, and 69 cases of wife to husband. It is impossible to write on this subject without referring to the very extraordinary experience of Dr. Weber, of London, in this matter of wife infection. He details nine cases of presumably phthisical husbands who communicated the disease to more than one wife. Twenty-one young and healthy

* *Case 53.*—In 1877 I attended a young man, aged 23, for phthisis; he died 25th May, 1877. His wife, a strong healthy girl of about 20, without any previous family history, as far as I could ascertain, of phthisis, *commenced to be ill in the early part of 1880,* and died of acute phthisis on 10th March, 1880. The house they lived in was very small, ill ventilated, and in a close, poor neighbourhood. Note that in this case two and a half years elapsed between the death of the husband and the commencement of the wife's illness, making it quite certain that she was not infected by him.

† *Case 191.*—Some years ago, the wife of an officer left Calcutta for Southampton in a sailing vessel with her husband. She stated herself to have been in perfect health when she stepped on board. Her husband was in an advanced stage of consumption, and died at sea. The voyage was stormy, the hatches down, the cabin hot and close. I saw her three days after her arrival at Southampton, with both lungs stuffed with tubercles. She was an only child, and had no hereditary predisposition. In this case the evidence is very conclusive of infection from the husband.

women married these nine men, and of these 21 unfortunates 19 died of phthisis. One man was supposed to be responsible for having killed four wives, another three, and so on. The singular thing about these cases is that the husband was supposed to be cured before he married, and one would think that a man who could survive four wives, as in the first case recorded by Dr. Weber, and show no breakdown in his health at the end of it all, must really have been pretty well. This, in fact, appears to have been the view taken of this extraordinary experience by Drs. Addison and Hughes, of Guy's Hospital, who were called in consultation on the illness of the third and fourth wives of this unfortunate man. They hesitated about accepting Dr. Weber's view of the case, as the husband might be regarded as cured. This controversy has led me to look into my own experience with regard to contagion in phthisis

With regard to phthisis in husband and wife, I have notes of seventeen cases among my own patients which resulted in death. In addition to these I have attended numerous cases of persons who either recovered or passed out of my observation, but I have not on any occasion known of the disease being communicated to the healthy partner; and in nearly all these cases the diseased and the healthy slept together for months or years in the same bed. The wife is more likely to be infected from a phthisical husband. I shall, by way of illustrating my experience, narrate six cases in which the husband died of the disease, and in which, with one exception, the wife slept with the dying husband up till within a day or two of his death. In the exceptional case, the wife slept in the same room in another bed, and nursed her husband until the day of his death.

Case 1. 1870.—Mr. N., master builder, æt. 30, suffering from phthisis, married a healthy young lady, æt. 24; went to Bournemouth immediately after marriage, and died there in seven months after; wife slept with him and nursed him, and remains alive and unaffected.

Case 2. 1872.—Mr. S., commission agent, æt. 38, died 29th September, 1872—ill two years. His wife, æt. 41, slept with him in the early stages of his illness, not afterwards, but nursed him till the time of his death. She was in the room with him night and day for the last three months of his life. Seven years after the death of her husband Mrs. S. began to cough, and now suffers from a chronic phthisis of the left lung.

Case 3. 1876.—Mr. M., master tailor, æt. 45, died after seven months' illness from phthisis; wife (æt. 37) and four daughters still alive and unaffected.

Case 4. 1877.—Mr. F., clerk, æt. 47, died from phthisis on 22nd September, after two years' illness; wife nursed him and slept with him till his death; wife and three children all unaffected.

Case 5. 1881.—Mr. W., commercial traveller, æt. 46, died from phthisis, 21st February, 1881. He had ailed for years; was confined to bed four months; wife and two children unaffected.

Case 6. 1888.—Mr. M., manufacturer, æt. 54, died in August, 1888, after seven years' chronic phthisis; wife and six children unaffected.

All these ladies are still alive, and, with the exception above stated, they remain healthy.

Case 7. I am at present attending a gentleman, æt. 35, who has been suffering from phthisis for at least five months. When I saw him first, a month ago, I found both of his lungs extensively diseased. I examined his sputum microscopically, and found numerous tubercle bacilli. No precaution was taken as to the disposal of this tubercular spit. Yet although this man's wife had slept in the same bed with him for four months, and two of his children had slept in a box-bed in the same apartment, the wife and the children remain up to the present time perfectly healthy.

I have in my note-book records of several families under my care in which one member after another died of this disease—for example, in one case a mother and five children, all of phthisis, in succession; in another case a mother and two children in succession; but the difficulty in the way of tracing these cases to direct contagion is the fact that, with the exception of the case of the first family mentioned, in which mother and daughter were ill together, and the mother appeared to take the disease from her daughter, none of the others were simultaneous cases. There was always an interval between the death of the one and the commencement of the illness of the other. When the interval was short, as in the case of a Miss B., where only a few weeks elapsed between the death of her sister in December and the commencement of her own illness in February, the probability of direct infection is increased. In my twenty-five years' experience I can only recall the cases of three families in which there

seemed to be a strong probability of direct infection, and in these cases the persons infected lived under very bad hygienic conditions; and there was, in addition, a probability of hereditary taint.

This leads me to consider what we know of the time which may elapse between the infection and the development of the tubercular lesion. Experiment has shown that in cases in which tubercular material, rubbed up with distilled water, was sprayed into the cages of animals used by Koch for experimental purposes, these animals, 217 in number, without a single exception, became tubercular within three or four weeks, and, when killed, showed numerous tubercles in their lungs and other organs.

In 1874 Demet and Zablonus, of Syra, in Greece, succeeded in inoculating a man of 55 with tuberculosis. The patient was dying of gangrene of the left foot, through obliteration of the femoral artery. Phthisical sputum was inserted into the upper part of the right leg, the lungs having been previously examined and pronounced healthy. Three weeks after the inoculation, signs of commencing induration of the right apex were detected, and seventeen days later the patient died of the gangrene. The *post-mortem* showed seventeen tubercles in the right apex, and a smaller number in the left apex, all evidently of recent formation. Under experimental conditions the incubation period may, therefore, be stated as from three to four weeks.

In ordinary practice, we must bear in mind that the dried spores in tubercular sputum may retain their vitality for six months; and, where no special care is taken with the sputum, there may be infection stored up in a house after the death of a patient for that length of time. We can thus understand a patient being infected during this six months' period when no disinfecting measures have been used. From these data we may conclude that any case which arises, after the lapse of eight months, in a house in which a phthisical person has died, has not arisen from infection derived from the previous case, but from some other source.

Are there Tubercle Bacilli in the Breath of Phthisical Patients?

There is a difference of opinion among modern authorities on this important question. As Nägeli, Carmichael, and others have proved by experiment that even strong currents of air are unable to detach bacilli or their spores from moist surfaces, it is

à priori improbable that the tubercle bacillus or its pores can be carried by the air currents of the breath from the moist cavities of diseased lungs through the moist air passages. Nevertheless, Dr. Ransome, of Manchester, and Dr. Williams, of the Brompton Hospital, London, state that they have found tubercle bacilli in the breath of advanced cases of phthisis pulmonalis; while, on the other side, Cornet states that he has never been able to propagate this disease by the inoculation in susceptible animals of the condensed vapours from the breath of phthisical patients.

An examination of the experimental basis on which Drs. Ransome and Williams found their opinion seems to me to show that these observers did not take sufficient care to climinate sources of fallacy in their experiments. I am satisfied that the bacilli found by Dr. Williams in the extraction shaft of the Brompton Hospital were much more likely to be derived from the spraying of the air of the ward with particles of sputum during the violent fits of coughing to which consumptive patients are liable, and to the drying of sputum on the clothing and on the floor of the ward, and its subsequent dissemination in the form of dust. There is no evidence whatever of its having been derived from the breath of the patients experimented on. The details of Dr. Ransome's experiments, as given in the 34th volume of the "*Proceedings* of the Royal Society of London," are quite insufficient to prove that precautions were taken to prevent the coughing of the patient, or the contamination of the air in the large glass globe into which the patient breathed with dust particles from the ward. Dr. Ransome states that in several cases of acute phthisis the search for the organism was unsuccessful, and that he only discovered the bacillus in two cases. As in the case of Dr. Williams' experiments, so in his cases the probabilities are that the bacilli were derived from particles either coughed out by the patient or disseminated in the air of the ward by dust particles from phthisical sputum.

In order to eliminate such sources of fallacy, I performed a series of six experiments in cases of advanced phthisis, which were under my care in the Victoria Infirmary, in the following manner :—

On the 5th of March last I examined the sputum of a young woman who had all the physical signs of tubercular disease of her right lung, with a cavity forming in the apex. I found,

on staining her sputum in the usual way with Gibbe's double stain, that it was crowded with tubercle bacilli. She was being treated in a side room in which there were no other phthisical patients. Her sputum was carefully collected in a spittoon, and she was prohibited from spitting on or into anything else. The room in which she lay was amply ventilated on the system of propulsion, warmed air being driven in through a shaft, the inlet of which was 5 feet above the level of the floor. The opening of the outlet shaft was at the floor level, so that any fine particles of sputum sprayed into the air in coughing would be carried out by the air currents at the floor level.

I smeared a glass slide with the sputum of a bronchitic patient which I found to be quite free from bacilli. I asked the phthisical patient to breathe upon the moist surface of this slide for a quarter of an hour every two hours during the day. This she did every day for a week. I cautioned her never to cough upon the slide, and each time, after breathing upon it, to place it, with the moistened side uppermost, in a small box with a lid, in which it was protected from dust. At the end of the week I stained this slide as stated, and examined it very carefully, with the result that I could not find on it a single tubercle bacillus. This experiment I repeated three times in the case of this patient, with a like result.

In three other cases of well advanced phthisis, with characteristic sputum in which the bacilli were demonstrated, I repeated this experiment with the same precautions, and with the same result.

First, on the theoretical grounds already stated; secondly, on the ground of the comparative rarity of the direct infection of healthy persons who are brought into close contact with phthisical patients, and who are constantly inhaling their breath; thirdly, on the ground of the negative results of Cornet's inoculation experiments; and, lastly, on the ground of the negative results of my own experiments just detailed, I am of opinion that neither tubercle bacilli nor their spores are ever found in the breath of consumptive patients.

This aspect of the question leads me to consider the defences of the healthy body against the invasion of the bacillus and its spores. Every one of us must at some time have eaten tubercular meat, drank tubercular milk, or breathed dust particles laden with tubercular bacilli; and yet, I suppose, most of us have

escaped tubercular disease. What prevented it? The most common avenue of entrance for this bacillus is through the lungs. Dried sputum of phthisical patients may be met with in every public vehicle, and in every public place where any large number of people assemble together. Some of it gets into dust, and occasionally we breathe it; but in a healthy state of the air passages, if this dust, by chance at an odd time, succeeds in passing through the moist passages of the nose and throat into the bronchial tubes, it is caught there by the mucus lining these passages, and, by the action of the cilia, carried up again and expelled. These epithelial cilia constitute the first line of defence. If, however, the mucous membrane is denuded of its cilia by repeated catarrhal attacks, such as most of us experience at times, so that the bacilli gain an avenue of entrance, the battle is not yet lost—we have an army of reserve to defend us. It takes three weeks for the enemy to propagate and increase his forces, and, in the meantime, he is vigorously attacked by the white corpuscles of the blood, which crowd to the point of invasion, and literally eat up the enemy and digest him. It is probably only when the breaches in first line of defence are numerous and extensive; when the enemy is in great force, and his forces are constantly replenished; and, further, when our second line of defence, the leucocytes, is weakened by the breathing of a bad atmosphere, and other insanitary conditions, that the bacillus can gain the victory. Such a combination of circumstances, fortunately for the human race, is only found at rare intervals in the average man or woman; and so we continue to defy the bacillus as long as we can continue to maintain our forces in good fighting condition.

In the case of the ingestion of tubercular food, similar protective forces are at work. We have no epithelial cilia lining the mucous membrane of the stomach or intestines to expel the intruders, but we have the daily action of the bowels to carry them down. If we keep our bowels in daily action, our mucous membranes healthy, and our leucocytes in good fighting trim, we do not need to fear the bacillus. Even if the enemy should effect a temporary success, there is still the hope that, by judicious treatment — a result of good feeding, fresh air, and healthy occupation—and without the use of drugs of any kind, our leucocytes may rally and destroy the enemy before he has time to increase his forces to any serious extent.

To sum up the whole matter from this point of view—I believe that tubercular diseases are always derived, directly or indirectly from pre-existing cases by contagious particles; but I am quite certain that in the genesis of the majority of the cases the contagium has been enabled to take effect only by the pre-existence of bad hygienic conditions, which have prepared and manured the tissues of the victim for the growth of the organism. In this way we may harmonise the views of the ultra-contagionists with the opinions of those experienced physicians who deny that contagion is the prime factor in the spread of these diseases. I hold that the facts which I have adduced establish the paradox that, while it is quite certain that phthisis pulmonalis is always got by contagion, yet the fact of contagion is of only secondary importance in the consideration of the preventive measures to be adopted to prevent its dissemination.

The most important causes which predispose man and other animals to offer a fitting soil for the growth of the tubercle bacillus are as follow:—

1. Heredity.
2. Breathing of impure air.
    - (*a*) From insufficient air-space, defective lighting, and bad ventilation in houses and workshops.
    - (*b*) Contamination of the air of workshops with dust particles and metallic vapours in certain trades.
    - (*c*) Contamination of the air of houses and workshops with sewage gases.

1. *With regard to Heredity.*—With our present knowledge, we do not believe that tubercle bacilli or their spores are directly transmitted to the offspring, either by the father or by the mother. But certain peculiarities of constitution are certainly transmitted, which favour the lodgment of dust particles in the respiratory passages, and favour the chances of growth for such tubercle germs as these dust particles may contain. Imperfect development of the chest and a tendency to catarrhal affections of the respiratory passages are the most usual transmitted predisposing causes. We may also reasonably suppose that, in consumptive families, the leucocytes have less than the normal amount of vitality and fighting power, so that they are less able to cope with and destroy the invading bacilli than the vigorous and aggressive

leucocytes of non-consumptive families. I fear we shall never completely remove the inherited predisposing causes, but we can do much to modify them by attention to—(1) the proper use of calisthenics in childhood to develop the imperfect lungs; (2) by attention to the purity and abundance of the air in sleeping apartments. I strongly urge the parents in such families to cultivate the habit of sleeping with the upper sash of the bedroom window an inch down at the top, and the chimney left quite free from obstruction, so that there may be a free circulation of the pure and wholesome *night air*, which, in a city, is the purest air we can breathe. In feeding their children, the greatest care should be taken to boil all the milk which they use, and to accustom them to overdone rather than underdone meat. There is no doubt that unboiled milk and insufficiently cooked flesh are a serious danger to such persons. Children should also be enjoined to eat fat, which, as a rule, they object to. When they reach maturer years they should choose an occupation which leads them into the open air, and, if it is possible, they should avoid large towns, and endeavour to live in an isolated, sparsely populated district, where they will be less likely to come into frequent contact with men and animals suffering from tuberculosis. If we could isolate consumptive families in such a way that they would never breathe tubercular dust or eat tubercular food, they would be absolutely safe from the danger of tubercular disease.

2. *The breathing of impure air as a result of insufficient air-space and of insufficient removal of the products of respiration, transpiration, and combustion.*—The evidence that, on the large scale, this is the chief cause predisposing to tubercular disease is most abundant. A consideration of the facts on record has led me to form the opinion that the contagiousness or the non-contagiousness of pulmonary consumption varies in direct ratio to the amount of air-space and of free ventilation of air in the dwellings of the people. Taking the factor of cubic space alone, Dr. Guy, many years ago, calculated that among 10,000 letterpress printers, in a work-room with air-space amounting to 800 cubic feet per man, 400 would die annually from consumption; while, of 10,000 men working in rooms with an air-space of less than 500 cubic feet per man, 1,200 would die in the same time—that is to say, as 3 to 1. The experience of barracks and prisons tells the same story. Previous to the inquiry of the Army Sanitary Commission in 1858, the cubic space per soldier in the barracks

of the Foot Guards was 331 cubic feet, and the mortality from phthisis was 13·8 per 1,000. In the Horse Guards, on the other hand, with a space per man of 572 cubic feet, the mortality from phthisis was 7·3 per 1,000. Since 1861 the cubic space has been increased in English barracks to 600 cubic feet per soldier, and ventilation and sanitary arrangements have been better attended to, with the result that the mortality from phthisis has been reduced to less than 3 per 1,000. As an example of the effects of bad ventilation in prisons, Dr. Parkes, in his "Practical Hygiene," adduces the case of the Prison of Leopoldstadt, at Vienna, which was very badly ventilated, and in which the mortality was 51·4 per 1,000 from phthisis; whereas, in the comparatively well-ventilated House of Correction, in the same city, the mortality from phthisis was only 7·9 per 1,000.

The case of the town of Kilmarnock illustrates remarkably well the improvement in the death-rate from phthisis which may result from a reconstruction of the old and insanitary houses of the poor. I quote from a letter on this subject, which I recently received from Dr. J. C. M'Vail, who was until recently the medical officer of health for that town:—"1. In 1861-70, Kilmarnock had the highest death-rate in Scotland, in either town or rural districts, from consumption. The 'actual' rate per million persons living was 3,881. What Dr. Robertson called the 'adjusted' rate was 3,346, but by both standards Kilmarnock had the worst rate of any population in the country. I enclose a cutting giving some of the 'adjusted' rates. In the five years, 1885-89 (the figures for 1890 being not yet available), the following were the *actual* death-rates per million—comparable, that is to say, with the 3,881 rate already given:—

1885	1886	1887	1888	1889
2,100	2,420	2,250	2,020	2,320

You will see what an enormous reduction is here. 2. It is not possible to give statistical data regarding the improved house accommodation. The improvement consists in the building of many new streets of workmen's houses of a good modern type—of increased cubic capacity; with walls lathed as well as plastered; with wooden floors ventilated underneath; with, in most cases, damp-proof courses in the walls; with slated roofs, and so on. These have taken the place of old, damp, thatched houses, with floors level with or below the ground, and often paved with brick

or with a rough kind of concrete, or merely with clay; with walls not lathed; without ventilation underneath the floors; with many of the windows fixed; with low ceilings, &c. A main cause of the great alteration was a local Improvement Act, which gave the Corporation extensive powers of sweeping away old streets and laying out new ones. The town spent a lot of money over the business, but it has had a magnificient return in its lowered death-rate from phthisis."

The theory that tuberculosis is highly contagious under the insanitary conditions just indicated, and non-contagious under proper hygienic conditions, explains many of the conflicting statements placed on record by trustworthy observers. For instance, the alarming mortality from phthisis among the Catholic nursing orders in Prussia, as shown by Cornet, who ascertained that out of 2,099 deaths from all causes among the members of these orders, phthisis was responsible for 1,320. I have no doubt that the reason for this alarming mortality is to be found in the fact that these devoted Catholic nurses spent their lives in nursing in the insanitary houses of the poor, where they were exposed to all the conditions which render phthisis an infectious disease. On the other hand, in the well-ventilated consumption hospitals of Brompton and Victoria Park, where the hygienic conditions were well attended to, the nurses are proved to have had almost complete immunity from tubercular disease. Out of 181 clinical assistants who have resided in these two hospitals only one has been known to become affected by phthisis during the period of residence; and of 356 nurses, some of whom have spent years in nursing consumptive patients, there is only one doubtful case on record of what looked like infection. On carrying the inquiry further, it is found that the proportion of these hospital attendants who became affected with phthisis after leaving these hospitals was also singularly small—in all, three clinical assistants and four nurses. This theory is equally successful when applied to the statistics of Williams, Copland, Cotton, Fuller, and others. With regard to the question of direct heredity, where the observations were made in private practice among the better classes living in good sanitary houses, the percentage was small—in Dr. Williams' observations, 12 per cent.; whereas in Drs. Cotton and Fuller's observations on hospital patients the percentages were more than double (24·1 and 25·7). In the latter case the insanitary houses from which the hospital patients

came made the difference. Similar observations apply to the lower animals. Tuberculosis increases among cattle in direct proportion to the extent to which they are confined in sheds and byres. Herds of bullocks fed chiefly in the open air are very slightly affected, and in the case of American cattle, which are never placed indoors for any length of time, tuberculosis is almost unknown. It reaches its highest percentage in the case of milk cows, chiefly because of the confinement of these animals in overcrowded and badly-ventilated byres. In considering the question of what can be done by the authorities, imperial and local, I shall endeavour to confine myself, not to Utopian or ideal enactments, but to what is practicable. First, I am of opinion that we cannot hope to deal effectively with tubercular diseases by methods of isolation and disinfection in the case of man, or of slaughter and destruction in the case of cattle. Take Glasgow alone. In round numbers we have had, taking the average of the last ten years, 2,000 deaths annually from tubercular diseases, and of these, 1,500 deaths are from phthisis pulmonalis. If my calculation of 10 patients for every death is approximately correct, there are at least 15,000 patients more or less dangerous, from the expectoration which they scatter abroad, a large number of whom are able to go about their business, and are quite ignorant of the nature of their disease. Under these circumstances they repudiate any constraint upon their freedom, and the very suggestion of their suffering from such a disease would be indignantly denied. In incipient cases it is sometimes impossible for an experienced medical expert to be certain of the presence of tubercle; and even when he is quite certain of it, he often finds it necessary carefully to avoid the name of consumption, as this would in many cases greatly alarm the patient, and prejudice his chances of recovery. In many cases he would look upon such an announcement as signing his death warrant. Then, again, it is extremely difficult to say, in a chronic case of phthisis, when the patient is absolutely safe. The tubercle bacilli may be absent from the sputum for weeks or months, and still the disease may be smouldering in the lung, and occasionally in an infective stage.

Again, these people are suffering from a disease whose duration is measured, not by days or weeks, as in the zymotic fevers which we are accustomed to isolate, but by years. Even if it were practicable to get the tubercular million of the popula-

tion of Great Britain to submit to be treated as the lepers of old were dealt with, the expense would be so enormous as to be quite prohibitive. In the cases of the workers in crowded workshops, and the dwellers in single apartments and rooms and kitchens, the sanitary officials might do great good by looking into the ventilation and sanitary condition of these places, and advising the people as to the disposal of the phthisical sputum, which we have seen to be the most dangerous material. Every death from phthisis should be notified to the medical officer of health, and, in view of the persistent infectivity of the spores of the tubercle bacillus, in such cases the sanitary officers should disinfect the house and clothing of the deceased, and inquire into the sanitary condition of his dwelling, and of the workshop in which he may have contracted the disease. It would also be possible for local authorities to enact that every room in a lodging-house or hotel which had been occupied by a consumptive patient should be thoroughly cleansed and disinfected to the satisfaction of the sanitary authority. The imperial authority ought to enact that on board ship consumptive patients should have separate sleeping accommodation. This is a most important matter, as the conditions on board ship, in respect to insufficient cubic space and bad ventilation, are the most favourable for the spread of the tubercle bacillus.

With regard to hospital accommodation for such cases, I think, on humanitarian grounds, it would be a great boon to the unfortunates who are refused admittance to our infirmaries, on the ground of their hopeless condition, if they were provided with a home, like the home for incurables, where they might end their days in peace and comfort. This would also tend to diminish the risk of infection which undoubtedly exists in the small, badly ventilated, and crowded houses of the poor. In the curable stages of the disease, I do not think there is any danger in treating cases of consumption in a well-ventilated general hospital, if proper care is taken to prevent the patients from spitting about the wards.

With regard to the question of what we can do with tubercular cattle, I think sanitary improvement in the byres and hygienic treatment of the cows are the only preventive measures which are likely to be effective. I do not think that we shall succeed in doing much good in limiting the spread of these diseases if we restrict our action to the slaughter of diseased animals

and the destruction of diseased meat. In the first place, the veterinary surgeons tell us they are not able to recognise the presence of tuberculosis in the living animal except in the later stages of the disease, and even then not with certainty, so that slaughtering is of little use as a preventive measure. In the second place, meat inspection, as at present carried on in Glasgow and elsewhere, is, as far as tuberculosis is concerned, most inefficient, and very little better than a pretence. Instead of being a protection to the public, it gives a false feeling of security, while, as a matter of fact, the danger is almost as great as if there was no inspection whatever. This is apparent when we consider that, while the amount of tubercular disease in cattle ranges from 5 to 20 per cent., the number of cattle condemned for tuberculosis in Glasgow is less than 1 per cent. In other parts of the country the meat inspectors are equally incompetent to protect us from tubercular meat and tubercular milk. Under these circumstances, no milk should be used until it has been boiled, and no flesh should be eaten until it has been thoroughly cooked to the centre. The cultivation of these habits will do more to protect us from this source of infection than any number of the most careful and competent inspectors can ever do.

The facts which have been adduced to-night seem to me to prove conclusively that, on the large scale, the greatest good can be got by the improvement of the houses and workshops of the people. What has been done in the prisons, what has been done in the army, and what has been done in our other public institutions, may be done in the crowded centres of population in Glasgow, if the authorities persevere in the policy of improving the house accommodation, and attending diligently to the other sanitary requirements of the people. As leprosy and typhus fever were abolished, not by leper hospitals and enforced isolation, but by improvement in the general sanitary condition of the people, so may the tubercle bacillus be deprived of the conditions which are necessary for its successful dissemination. As a result of the renovation of the old and insanitary houses of the poor, the mortality from tubercular diseases has already been greatly diminished in this country; and by the general adoption of sufficient cubic space and proper ventilating appliances in the dwellings of men and animals, the ultimate extinction of tuberculosis may become a possible achievement.